Center for Independent Experts (CIE) Peer Review of the Atlantis Ecosystem Model in Support of Ecosystem-Based Fishery Management in the California Current Large Marine Ecosystem

Daniel Howell
Institute of Marine Research
Bergen, Norway

Executive Summary

In general, ecosystem modeling frameworks (such as Atlantis), give a broad overview of the functioning of an ecosystem. This comes at the expense of creating a highly complex model for which full data is not available, and which is in any case too complex for formal statistical tuning to that data which does exist. As such, these models can give qualitative understanding of ecosystem function and possible responses to management action, but cannot reliably give precise quantitative answers (for example stock levels or reference levels). The Atlantis model under development for the California Coast Current is a relatively detailed and thorough version of such a model, and thus has the potential to give quantitative understanding of the ecosystem for use in practical management. It is clear that the model has the potential to address a wide range of topics in ecosystem management, and further development and review is encouraged.

One key difficulty with the review was that the model in question is in the process of being improved. A previous version is available with a detailed description (Horne et al. 2010). A number of critical issues were identified with this model, which would make it difficult to recommend this version for practical use in management. A new version is in the process of being constructed and tuned (Kaplan et al. 2014). It appears that this new version attempts to address many of the issues identified with the previous version, and thus has the potential to be of practical utility. However as no results were available it is not clear to what extent this has been successful. Consequently the best that can be accomplished at this point is to identify potential improvements in the developing model, and outline the acceptance criteria and possible areas of use of the final model. It is not possible, at this stage, to definitively accept or reject the model for any particular use.

The new version improves the area structure (both in terms of the number of areas considered and in extending the range over a wider area), and increases the number "functional groups" (the key model element consisting of one or more similar species). In particular the pelagic fish have received considerably more attention than previously. There are several areas identified as problematic in the 2010 version that are not currently improved in the new version. In particular early life history dynamics, especially of long-lived species, are very poorly modeled. The model also has rather limited focus on lower trophic levels, being much more detailed on the level of fish and top predators. Consequently one should be extremely cautious in using the model to evaluate effects mostly occurring in the lower trophic levels, especially including ocean acidification. It is not clear that the model has sufficient detail to evaluate the overall impact of dynamic interactions between different species in the lower trophic levels.

On the model acceptance question, it is important that key acceptance criteria be decided before the testing the model, which should relate to the level of realism and consistency in the model. This would identify that the model performs adequately overall, and can be considered in more detail for particular tasks. Such criteria are not standardized for Atlantis models, and would need to be formulated for this particular model and ecosystem. These criteria can then be used to form an objective measure of the ability of the model to be of use in management. Many of the criteria are already part of the diagnostics currently used within the model development, including the biological realism of life histories, stock and consumption levels, rough fit to historic biomass trends for important functional groups, and non-extinction of functional groups.

Assuming the model can demonstrate that it passes the tests described above, it has potential to be used in giving qualitative advice and in ranking possible management actions. However, before use on any particular problem the model should be evaluated again for the suitability of the model for that particular problem. This should include both how well the model captures the relevant ecosystem dynamics and the level of precision and reliability required for management. The model results should not be taken as giving advice on exact quantities, stock levels, quota levels or reference points. In general, to avoid confusion, it would be wise to only present results as rankings or "% change from base case" rather than give exact (but highly unreliable) model outputs.

It is possible to identify several limitations which are not likely to be fixed in the forthcoming version. The Atlantis modeling framework in general has poor resolution on the early life stages of the fish, mammals and seabirds. Results for recruitment and within the first age category for each functional group are therefore best considered as internal model parameters rather than as reflections of reality. Furthermore the model, as currently structured, can be considered as a multispecies fish-seabird-marine mammal-fisheries model with limited realism in the lower trophic levels. As such, results are likely to be rather less reliable on the lower trophic levels than for the vertebrates. In addition, it is not clear that issues relating to extinction of functional groups and misfits to historical time series will be resolved by the model improvements. Any use of the model should be very clear about such limitations, and the model should only be used in ways that are not impacted by any known limitations.

Background

This document presents an independent review of the Atlantis Coastal Current model (CCAM) conducted by Dr. Daniel Howell of the Institute of Marine Research (IMR) of Norway on behalf of the Center for Independent Experts (CIE). The review took place at the Northwest Fisheries Science Center (NWFSC) in Seattle, Washington, between 30 June 2014 and 2 July 2014. The review focuses on the utility of the model in integrated ecosystem assessments. In particular the comments on the methodology and application are limited to the utility of the model and application for this purpose, rather than as a more general evaluation of the methodology.

Description of role in the review activities

Dr. Daniel Howell has a background in stock assessment and minimum realistic multispecies modeling. Consequently his main participation in the review was to discuss the detailed formulation of the multispecies parts of the model. In particular this focused on potential limitations or weaknesses of the model formulation (e.g. smooth recruitment, handling of the youngest age classes). This review therefore will not contain much detail on the oceanography or lower trophic levels (below fish), owing to lack of expertise in these areas. It should be noted that the detail on the lower trophic levels is, in any case, rather limited. As described below, the model is in the process of development. This review therefore attempts to identify potential areas for improvement in the existing model, highlights potential weakness which may not be easy to address, and discusses in relatively general terms the model's potential applicability to different ecosystem management questions.

Findings of accepting or rejecting the work

One key difficulty with the review was that the model in question is in the process of being improved. As a consequence, the model was not considered to be fully accepted or rejected by the panel for any of the possible uses in the terms of reference. A previous version is available and detailed in Horne et al. (2010). A number of critical issues were identified with this model which would make it difficult to recommend this version for practical use in management. The model had two different functional groups going extinct (one benthos group, and kelp) during the model run. The kelp extinction in turn affects the habitat suitability within the model. Furthermore, although the majority of the functional groups showed "reasonable" historical fit to the available data, the ones that did not fit were some of the most important, including hake and the main pelagic fish. A new version has been constructed and is in the process of being tuned (Kaplan et al. 2014). This new version attempts to addresses many of the issues identified with the previous version, and thus has the potential to be of practical utility. However, as no results are available, it is not clear to what extent this has been successful. Consequently it is not possible to accept or reject the work in general at this point, nor to identify which topics the model is suitable for. The model definitely shows promise, and has already captured many (although not all) key ecosystem dynamics. Further development of the new version of the model is encouraged. There are a number of issues identified as problematic which are not currently included in the development of the new model, either from a design choice, lack or data, or limitations in the Atlantis code. As these may limit the application of the model the main weaknesses are briefly described here.

This review will therefore briefly discuss the acceptance process in general before such a model should be taken into use for any given management application. As discussed in the following sections it was considered that the model makes a valuable contribution to the understanding of the California Coast Current ecosystem, and that the model has the potential to be used directly in ecosystem management once the revised model had been evaluated.

Acceptance procedure

"Accepting" the model should be considered an ongoing and multi-stage process. An initial stage is to test if the model overall captures the main dynamics of the ecosystem in a realistic manner. It is important that the key acceptance criteria for this be decided before the testing the model, and these criteria should relate to the level of realism and consistency in the model. These criteria can then be used to form an objective measure of the ability of the model to be of use in management. This test would identify that the model performs adequately overall, and can be considered in more detail for particular tasks. Many of the criteria are already part of the diagnostics currently used within the model development, including biological realism of life histories, stock and consumption levels, rough fit to historic biomass trends for important functional groups, and non-extinction of functional groups. A decision on these acceptance criteria should be made collaboratively between the researchers and the management body.

Assuming the model can demonstrate that it passes the tests described above, it has potential to be used in giving advice in a range of ecosystem management situations. However, before use on any particular problem the model should be evaluated again for the suitability of the model for that particular problem. This should include both how well the model captures the relevant ecosystem dynamics, and the level of precision and reliability required for management. For example, the CCAM model is weaker in the first age category than for modeling older individuals. Thus while evaluating a management plan which focused on SSB may not be compromised by this limitation, using CCAM to evaluate a management strategy which stressed juvenile survival rates would be more difficult to justify. In general the applicability of any model to any particular management role will require detailed consideration of this kind, and broad generalizations may therefore not be appropriate.

On present evidence it is not possible to state definitively which problems, if any, the model should be used for. However it is clear that the model has the potential to address a wide range a topics in ecosystem management, and further development and review is encouraged. It is possible to identify several limitations which are not likely to be fixed in the forthcoming version. The Atlantis modeling framework in general has poor resolution on the early life stages of the fish, mammals and seabirds. Results for recruitment and within the first age category for each functional group are therefore best considered as internal model parameters rather than as reflections of reality. Furthermore the model, as currently structured, can be considered as a multispecies fish-seabird-marine mammal-fisheries model with limited realism on the lower trophic levels. As such, results are likely to be rather less reliable on the lower trophic levels than for the vertebrates. Finally the fishing model is rather oversimplified, which limits the relevance of at least some fisheries related applications.

ToR 1. Review documents detailing Atlantis ecosystem model methodologies according to the PFMC ToR for the Methodology Review Process for Groundfish and Coastal Pelagic Species. Evaluate if the documented and presented information is sufficiently complete. Document the meeting discussions and contribute to a summary panel report.

In general the documentation provided was adequate for the task of evaluating the model as it was structured in 2010, and to gain an overview of the potential applications considered by the researchers. Full documentation on the new version of the model was not available, as this version has not yet been tuned. The documentation was thus not sufficient to evaluate the performance of the revised model. The documentation provided split into several technical reports on the model structure, result and diagnostics, together with a series of academic papers detailing applications of the model.

Horne et al. (2010) provided a reasonably thorough overview of the model structure and results. Dufault et al. (2009) gave a description of the available knowledge of the predation interactions in the region. Together these provided a good description of the 2010 version of the model, with only minor omissions. It is not altogether clear from the Dufault et al. (2009) paper what level of accuracy is implicit in each of the datasets. The point estimate for each interaction is given, but the details lie buried in a large number of source documents. Kaplan et al. (2014) gave a description of the updated model structure as it exists at present (and states that this an ongoing revision of the model). However without tuned model results (especially diagnostics on extinction, historical fits to data and plausibility of life history characteristics), it is not possible to make a judgment on this version of the model.

The peer-reviewed papers covered both general ecosystem modeling issues (e.g. Fulton et al. 2011) and specific applications of the model to particular problems. In all cases these were research papers, rather than being management documents. In general they give an overview of the potential range of applications of the model, but as they utilize the older version of the model they do not in themselves form a basis for adopting the model into management for any of the applications. Kaplan et al. (2012a) gave a description of a method for assessing the relative impacts of management strategies, while Kaplan and Leonard (2012) attempted to extend this to economic and social impacts. This latter work was rather undermined by the coupling of a long-term Atlantis model to a short-term economics model. Kaplan et al. (2013a) modelled the impact of depleting forage fish; however the version of the model used was lacking in detail on the forage fish part of the system, and the linkages identified should thus be treated as tentative at best. Three papers (Kaplan et al 2010, Kaplan et al. 2012b, Kaplan et al. 2014) considered fisheries interactions with the ecosystem. These all relied on rather simplified fishing patterns (e.g. constant F and equal effort across all open polygons within the model), and thus the utility of the results in real world management is limited.

One additional document (Kaplan et al. 2013b) was made available in response to a request. This details the other whole ecosystem or multispecies work on this region. This is of critical import in deciding which of the available tools are best suited for any particular issue. In addition to the Atlantis model only one model focusing on lower trophic levels (NEMURO_SAN) and an EcoSim model are available, and no multi-species models are available. Thus for many higher trophic level questions the Atlantis model under development is the only potential model that could be used, whereas for lower trophic level issues there is a choice of two models (or a combination of both) available. The level of information on the alternate models was rather brief, but sufficient for present purposes considering the unfinished state of the new Atlantis model. If the revised Atlantis model is seriously considered for management applications, especially for questions related to the lower trophic levels, more details of the alternate available modeling tools would be required in order to decide which of the models was most appropriate for any given question.

ToR 2. Evaluate the technical merits and deficiencies of the proposed method(s) taking into consideration the data requirements of each method, the conditions under which the method is applicable, the assumptions of each method, and the robustness of model results to departures from model assumptions and atypical data inputs. Recommend alternative methods or modifications to the proposed methods, or both, during the panel meeting. Recommendations and requests for additional or revised analyses during the panel meeting must be clear, explicit, and in writing. Comment on the degree to which the methods describe and quantify the sources of uncertainty in the results.

The Atlantis modeling framework is a state of the art tool for creating whole ecosystem models. It allows for considerable complexity and realism in spatial structure and temporal resolution of the model, as well as allowing a large number of biological “functional groups”. These can consist of single species or a group of species with similar characteristics. This allows for flexibility in giving priority to key species while still including more minor ones within the model. The main unit of the model is nitrogen, taken as a proxy for biomass. The framework allows for oceanography to be taken from specialized ocean models, incorporates environmental drivers, and models all biotic components from bacteria through to top predators such as marine mammals. The model also allows for detailed modeling of each of the model areas, with predation as the main interaction. In addition density dependent terms can be introduced, either for actual density dependence (spatial crowding) or as a proxy for food limitation that may be difficult to model explicitly. The model also allows for moderately detailed fisheries modeling, with multiple fleets, each with its own selection, area distribution and fishing level. In principle this combination of biological and spatial realism allows for detailed analysis of ecosystem functioning.

The major limitation of this high degree of complexity is that the model has an extremely high degree of complexity. It is generally not possible to obtain sufficient high quality data to parameterize all of the modeled components, nor is there any statistical tuning of the model to data. Rather, the model requires the model developer to tune the (large number of) parameters by hand in order to obtain a model that “looks right”. A range of diagnostic measures can be used to identify if the model passes this test, including testing life history traits (size, growth rates, mortality), fits to known historical trends, however these only give confidence that the modeled ecosystem is “similar” to the one studied. The precise process for this particular model is described in under ToR3. The lack of tuning to data is a major (and probably unavoidable) weakness of the model, leading to doubt as to the accuracy of any solution. It should be noted that this complexity also results in a long run time, meaning that multiple runs, such as sensitivity tests, cannot be conducted in the context of a review or assessment meeting.

Furthermore the high degree of complexity in the interactions almost certainly introduces a number of unquantifiable errors into the model. There are simply insufficient data and scientific understanding to parameterize everything in an ecosystem correctly. Consequently, although outputs from the model may represent the best available ecosystem modeling, they are best interpreted in a qualitative rather than a quantitative manner. The modeling tool is not suited to giving precise levels such as stock biomass or reference levels. It may be possible to use the tool to rank a series of different scenarios (for example different management options), but this would need to be carefully evaluated on a case-specific basis.

One key deficiency is in openness and accessibility. Although there are a number of published articles describing the model methodology and specific examples, neither the code nor the documentation are freely available. Both are available on request, and at present such requests are all accepted. However there is no guarantee that this will continue to be the case. There are obvious dangers in basing a management tool on computer code that does not come with a guarantee of continued availability. There are also obvious pitfalls in relying on code that does not have freely available documentation.

The model does not quantify uncertainty in the outputs, and it is not obvious how it could do so. As the model is not statistically fit to the data, standard methods of estimating uncertainty cannot be applied. Furthermore the long run time would, in any case, rule out many such techniques. One possible way forward is to construct a number of parameter sets, each of which produces an adequate model of the ecosystem. With such a set of scenarios the likely range outcomes can be explored, even if probabilities cannot be directly assigned to any given scenario. However, while this approach may be useful in theory, in practice it relies on finding multiple solutions that all give good fits to historical trends, plausible life history traits for all groups, and avoid extinctions among the models functional groups. To date no such solution has been found.

Limitations of the Atlantis code

In addition to the general issues mentioned above there are several technical limitations within the Atlantis code which constrain the flexibility of the model, and hence limit the realism that is possible. These are not directly addressable by the development team at the NWFSC. The limitations do not preclude the use of the model, but should be borne in mind when selecting the tasks for which the model is used.

- For recruitment it is possible to specify a smooth SSB-recruitment relationship, possibly including environmental factors. It is also possible to specify a time series of recruitment values (independent of SSB). It is not currently possible to implement a SSB-recruitment relationship with annual deviations, and thus it is not possible to realistically model species with inherently variable recruitment. This would be a relatively simple modification (especially as optimization is not an issue for Atlantis). It is therefore strongly encouraged that the modeling group press for this to be added to the code, as this is the most realistic manner of modeling stocks with highly variable and erratic recruitment.

- For any given functional group there are a maximum of ten evenly spaced age classes. In general life history traits (e.g. growth, feeding, mortality) vary rapidly in the early life stages. Consequently this even spacing will result in rather unrealistic modeling of the earliest one or two age categories. For single species it is possible to move to actual age classes, and it is recommended that this be done for the hake. Even where this is done, care should be taken in interpreting results in the youngest age class. The model assumes "recruitment" at 90 days. An organism at 91 days typically has very different characteristics from one at 365 days.

- The Atlantis model does not currently allow for dome shaped selection functions for predators; rather there is an upper limit on how large a prey can be eaten by a particular predator. In some cases this can be rather limiting. In reality much of the selectivity pattern may be explained by spatial overlap of predator and prey, however it is not obvious to what extent the spatial grid implemented here will reproduce this for any given predator-prey relationship. Where there is known to be dome shaped selectivity the model should be examined to see how closely it can reproduce this.

- The modeling of the fishing fleets is also rather limited. Fishing is set at a constant F, rather than following a harvest control rule. This both limits the accuracy of fitting the model to historical reality and the range of management scenarios that can be examined.

In summary, the Atlantis model represents a state of the art attempt to model an entire ecosystem in a realistic process-based manner, and as such it can provide insights that are not available from other modeling tools. However the results must treated with caution, regarded as qualitative, and need to be considered alongside a knowledge of the limitations of the modeling tool. In particular, care must be taken that the proposed application relies on the strengths of the model rather than the weaknesses identified above.

ToR 3. Evaluate technical merits and deficiencies of the application of the methodologies.

It is difficult to be specific about the application of the methodologies (i.e. the specific CCAM model), given the current ongoing work on improving the model. The section therefore outlines the previous version of the model, and identifies where the new version has corrected structural weaknesses. It should be stressed that it is not yet clear if these structural improvements will result in improved model performance. In principle the revised version has the potential to address many questions, especially around higher trophic level dynamics. Several areas are identified where structural weaknesses remain which may limit the range of problems the model can be used to address.

The model presented in Horne et al. 2010 could be characterized as an extended multispecies model, or a groundfish-centric ecosystem model. The model area concentrated on the coast and near coast environments, and did not extend to the main pelagic regions, or the northern or southern extremes of the distribution of many of the populations modeled. This means that many key species spent part of the year outside the main model area. The Atlantis model can handle this, and it is inevitable that some populations will migrate in and out of any constrained model domain. However the model does not model such populations well, and it is therefore desirable that the model domain covers the full distribution of the main populations. On the species side there are functional groups for 4 primary producers, 4 zooplankton, 18 invertebrates, 26 fish, 3 seabirds, and 6 mammals. The fish groups are heavily concentrated on groundfish, with combined functional groups for pelagic species. It can be seen that rather more than half of the focus of the model is on the higher (fish and upwards) trophic levels. Diagnostics were presented indicating that for many groups the life history traits were realistic, and that the historical trends approximated those available from other sources (e.g. stock assessments). However, a critical weakness of the model was its inability to come close to historical trends for the several of the main fish populations (including the main pelagics and hake). This may have been due to the lack of realism described above. The model also did not produce realistic results for salmon. However this is not unexpected given the rather specialized life cycle of these fish and the rather generic structure of the fish population models within Atlantis. It is unlikely that Atlantis will give realistic results for salmon without development of a specialized salmon component. Alongside the intrinsic life history parameters (growth, reproduction…) for each functional group, predation interactions (especially predation-induced mortalities) are the main drivers of the Atlantis model. Obtaining data to fully parameterize these across all the major groups over a whole ecosystem is obviously challenging, and one must expect that there are limitations in how this can be parameterized. One key simplification that has been made here is that diet composition is taken as a point estimate, with an implicit assumption that this has not changed over the model time period. Consequently any major changes in prey selection over the time period from 1950-present will give rise to model mis-specification during the model construction and tuning phase.

The improved version that is described as ongoing in Kaplan et al. (2014) extends both the biological and spatial detail. In spatial terms the model now has a pelagic zone to the west of the continental shelf, and extends north into Canadian waters and south into Mexico. At both extremes there are data limitations, meaning that results from these areas are less reliable than from the core area. However the extension is valuable as it means that the main populations (now including Pacific sardine and Pacific hake) can now be dynamically modeled throughout their life cycle. In biological terms, the new version greatly improves the modeling of the key forage fish in the ecosystem. Pacific sardine, northern anchovy, Pacific herring, Pacific mackerel, jack mackerel, and Pacific hake are all modeled are individual species, although mesopelagics remain as an aggregate functional group. This gives the possibility of rectifying the historical mismatch in forage fish biomass. It should also improve the modeling of forage in general, with consequent improvements in the overall functioning of the food web interactions within the model. Finally this new species resolution extends the range of problems which can be addressed.

On key weakness which is not addressed by the new model is that the start date of 1950 is taken to be a proxy for unfished conditions. The model is run to stability without fishing as a burn in period to reach this "start date". In fact significant fisheries existed on a number of stocks prior to this date. This means that tuning the model so that the stable unfished state matches the stock levels in 1950 will give erroneous dynamics for some stocks. Oceanography and lower trophic levels are beyond the area of expertise of this individual reviewer, and will therefore not be discussed in detail. However from the panel discussion these appear to be rather simplified versions of reality. These simplifications are probably necessary given the state of the art, but may limit the realism of the model. As such the model may be better suited to give information on the vertebrates within the ecosystem than on the lower trophic levels.

Given the rather ad hoc nature of tuning an Atlantis model, the precise methodology used becomes critical. In the case of the CCAM model the process was as follows. A range of parameters for upper (unfished recruitment, maximum consumption rates, interaction parameters and mortality closure terms) and lower (maximum consumption rates, interaction parameters and mortality closure terms) trophic levels were manually adjusted to achieve desired model performance. There was no specification of the order in which parameters were adjusted. There were a series of phases of the tuning. First the model was projected from initial conditions (set to approximate those in 2007) with zero fishing in order to obtain an estimate of the unfished state. This was compared with the stock estimates for 1950. However there are several problems with this methodology. First, as mentioned above, not all stocks were at unfished levels in 1950. Secondly, the model was projected forward for 80 years, which was an insufficient length of time to reach the desired stability. Finally not all species could be kept alive under this testing. The model was then projected forward from the unfished state obtained in phase 1 under historical catch levels in order to try and match the historical time series of biomasses. Again there were difficulties in that several key groups did not match the historic time series, and that others were driven extinct before the present was reached. An additional series of tests were run in which constant fishing was applied over time in order to compare model results to MSY estimates. These runs were able to highlight that the modelled hake stock in particular seemed overly resilient to fishing, suggesting an overly high level of productivity. In general the tuning process suffered from a predetermined definition of successful tuning, and perhaps pressure to move to utilizing the model before it had been fully tuned.

ToR 4. Decide through Panel discussions if the ToRs and goals of the peer review have been achieved and determine whether the science reviewed is considered to be the best scientific information available. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all of the ToRs must be described in the Summary Panel Report and CIE Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations

It should be noted that only a draft version of the panel report (from 12.07.2014) was available at the time of writing this report. In general the review was not able to come to definitive conclusions given the "in progress" nature of the model upgrade, but the consensus was that the modeling was a valuable initiative with potential to be useful in management and should be developed further. The panel review had two groups of terms of reference. The first related to properties and potential applications of the CCAM model, the second related to the technical merits of the methodology. The review process did not attempt the (excessively large) task of fully describing either Atlantis or the CCAM model. Rather the discussions and the report produced summarize the main characteristics of this model and detail the extensive panel discussions on model formulation and performance. These discussions and the report focus almost exclusively on the specific model presented, rather than the Atlantis modeling tool as a whole. Thus while panel ToR 1 (strengths, weaknesses, appropriate uses, and potential areas of improvement for the Atlantis models with respect to these management needs) was extensively addressed, panel ToR 2 (Reviewers will be asked to comment on the technical merits and/or deficiencies of the methodology and recommendations for remedies) focused more on this implementation of the methodology than on the methodology itself. Given the large scale of the Atlantis model, this focus is probably both desirable and largely unavoidable. For this second group of panel ToRs, the panel discussions and conclusions are summarized in the preceding sections. For the specific panel ToRs on possible applications, a point by point summary is given below. Apart from the limitations mentioned above (regarding the limited comment on the Atlantis methodology in general and the inability to make firm recommendations in the absence of a finalized model version) the panel generally addressed all of the terms of reference.

In general there are no significant areas of disagreement between this review and the panel review, given the collaborative nature of the review process and the overall level of consensus reached. However there are several important points which are not highlighted in the (draft) panel report. One point which was not brought out was the higher level of detail (and thus reliability) in the model for higher rather than lower trophic levels. This is essential to bear in mind when deciding on the applicability of the model for a particular task. In the panel ToR 1d the panel took "informing parameters" to mean "setting parameters", and accordingly rejected it. However the CCAM model may be able to give other, background, information. For example the model can indicate which are the main interactions to consider for any stock, or if there are important spatial or temporal variations. This is useful information in designing assessment models, even if the CCAM value is not used directly. Other than this, the panel report captured what this reviewer considers to be the main relevant points of the evaluation. The CCAM model is clearly the best scientific tool currently available for modeling the large-scale ecosystem interactions, the question of whether the revised model is sufficiently accurate to be of use in management is deferred until that version is available for study.

Overview of the discussions and report on Panel Tor 1, specific potential applications of the CCAM model

Tor 1a (foodweb impacts of fisheries)

As noted by the panel there were large differences in predicted response between EcoSim and Atlantis, which the panel linked to EcoSim being predominantly a bottom-up (food availability) model, whereas Atlantis is mainly a top-down (predation mortality) model. The panel also noted that there was currently insufficient detail in the forage fish for these to be considered in detail, meaning that these are currently a weak link in modeling effects on the food web. Until the new version is completed and evaluated it is not clear to what extent this limitation will be resolved

Tor 1b. Ranking of potential fishery management strategies

The panel report summarized the published papers on evaluating management strategies. It is clear that there were several oversimplifications in the fisheries modeling (assuming constant F rather than a Harvest Control Rule, assuming uniform distribution of effort in the absence of data), but that in general the approach does have utility. The attempt to link this to social and economic impacts was undermined by the choice of a short-term economics model to link to the long-term Atlantis model, and the consensus was that this was not a valid approach.

Tor 1c (Evaluation of risks of climate change and ocean acidification)

The panel report stated that the model had the potential to address this issue, but noted that care was needed in interpreting the results in order to avoid a misleading impression of precision. However the panel report does not highlight the lack of detail and biological realism in the lower trophic levels, with a wide diversity of organisms collected into a small number of functional groups. This means that the likely changing mix of organisms in response to environmental stressors cannot be modeled, and that the model is therefore likely to be far less accurate on the response of these groups than of fish.

Tor 1d (Informing parameters within single species assessments, e.g. M)

As stated in the panel report, the CCAM model is parameterized based on single species assessments, and using the Atlantis values directly in these assessment models becomes dangerously circular. In addition, the use of the CCAM model in such a deterministic manner gives too much weight to the specific (and uncertain) value. Furthermore the lack of an estimate of the uncertainty would damage the ability of the assessment models to estimate uncertainty. However, as discussed above, there are other more qualitative ways in which CCAM could usefully "inform" the single species assessment models.

Panel ToR 1e (Formal Management Strategy Evaluation)

CCAM and Atlantis, in general, are ideal tools for generating known artificial environments for use in management testing. It is important however to be aware that the test data are artificial, and that simply "passing" a test based on this does not guarantee that the strategy would be appropriate in the real world. Additionally, although perhaps less likely, a strategy may "fail" the test to artificial data but be successful in real world management. In both cases one must be aware that all fisheries models contain model mis-specifications, and that complex models must contain more such mis-specifications, and these can impact on the reliability of any results. As such the Atlantis model could form one part of the process of testing and accepting new management strategies.

ToR 5 - Provide specific suggestions for future improvement in any relevant aspects of data collection and treatment, modeling approaches and technical issues.

Some wide-ranging suggestions for how to use the model, and possible caveats around its use, are given in the Conclusions and Recommendations section below. Specific actions are detailed here.

- The Atlantis model should developed as part of a suite of modeling tools to give best coverage of different management questions. In addition to Atlantis, single species assessment models, statistically rigorous multispecies models and specialized lower trophic level models would synergize to give a better understanding of the processes and provide more robust answers to a smaller subset of the potential issues.

- The inability of the previous version model to fit to the historical trends of the main biomass groups (e.g. hake, major pelagic groups) is extremely worrying. At best it reduces the range of questions that can be asked, and at worse undermines any confidence in the model results as a whole. Hake are a major part of the biomass and a significant predator, and the poorly fit pelagic groups represent the main forage fish component. It is therefore strongly recommended that development of the new version continue until these mismatches are addressed.

- Two functional groups go extinct in the previous version of the model. This should ideally be avoided in the new model. If extinctions cannot be prevented then the extinct functional groups should be excluded from the model, and the model formulation evaluated on the basis that these groups are not included. In general, extinction indicates model mis-specification, and is a sign of a poorly configured model.

- Tuning runs that aim at reaching stability should be long enough for stability to be reached. It may be that most runs during development do not need to be this long, but the final runs used for evaluating the model should be of sufficient length.

- It appeared from the presentations that Isaac Kaplan was critical to the successful development and use of the model. As a research project this may be acceptable. However, given the complexity and steep learning curve of the model, it could become problematic from a risk management point of view if the model was to be accepted for use in practical management. An ongoing core group of researchers is therefore recommended if the model is taken into use in management. This is likely to become essential in any case if the model is heavily used in management.

- At present the code and documentation of the Atlantis model are only available on a by request only wiki. In order to use the program in practical management one would want that at least the documentation to be freely available. The lack of freely available code should also be considered by any management body prior to relying on any models generated from such closed code.

- It is strongly recommended that the modeling group press for the ability to add deviations to SSB-recruitment relationships to be added to the code. Without this relatively simple addition it is not possible to model stocks with sporadic recruitment, nor to evaluate the effects management actions during periods of poor recruitment.

- The age structure for the model components should be examined carefully. Where appropriate the age structure for single species functional groups should be converted to actual ages. All functional groups should be examined to identify where the first one or two age categories cover a wide range of life history traits. These cases should be identified, and extreme care taken in any application which utilizes results from these age categories.

- On the lower trophic levels the results should be compared to those from other available existing models (e.g. NAMURO-SAN). One would not necessarily expect the same outputs, however the overall trends, absolute levels and variability should be compared.

- In general it is recommended that extreme care be taken in using results from the model on the early life stages of the stocks (within the first one or possibly two age categories) and on the lower trophic levels. These are the parts of the ecosystem that the model oversimplifies the most.

Conclusions and recommendations

The California Coastal Current Atlantis model (CCAM) reviewed here has potential to be of use in both theoretical research and informing practical ecosystem based management. As a whole ecosystem ("End2End") model it gives a broad picture that is not available from many of the other possible modeling tools. The CCAM model has been under development for some time, and it is recommended that this development be continued. The model is approaching a level of maturity at which it could be considered for use in management, and the ongoing work on improving the model is directed at addressing many of the main weaknesses in the older version. However, because of this ongoing major revision to the model it is not currently possible to assess the model, nor evaluate its relevance for specific management problems. Although the improvements are well designed to address many of the weaknesses identified in the previous version, until the model is fully tuned it is not possible to say how successful the improvements have been in rectifying those problems. Consequently this review cannot recommend the acceptance of the model at this time. Specific recommendations for technical model improvements are given in the previous section, and more general overall recommendations are given here.

It is therefore recommended that once the new version has been full parameterized and tested, a new evaluation be conducted to assess the overall fitness of the model as a representation of the California Coastal Current ecosystem. Criteria for judging this should be agreed in advance of the evaluation between the research team and the management board. This evaluation should assess the overall ability of the model to capture the main features of the ecosystem, and could perhaps suggest areas where the model could be relevant to management. However for any given application a further evaluation would be needed, considering how the strengths and weaknesses of the model relate to the particulars of the management task. For example, the model is weaker in the first age category than for modeling older individuals. Thus while evaluating a management plan which focused on SSB may not be compromised by this limitation, using CCAM to evaluate a management strategy which stressed juvenile survival rates would be more difficult to justify.

In general, one must be aware that there is a diversity of realism between the model components. Some stocks and potentially fisheries exist partially outside the model area. This is inevitable in any spatial model; however one should be aware that results for these stocks may be less reliable than for those stocks entirely within the model area. Equally the level of realism on certain species (typically in the higher trophic levels) is much greater (with more detailed modeling and much higher quality of data and biological knowledge) than for others. This is equally true for fisheries, where there exists different amounts of information on different fisheries. In general this restricts the range of topics which the model can address, or at least the level of precision that can be applied to different topics. This requires that the model be individually evaluated for each proposed application, with the model being generally less well suited to questions involving early life stages and lower trophic levels than to higher trophic levels.

The Atlantis model is not statistically fit to data, nor is it reasonable to expect this of a whole ecosystem model. As a result the model does not give a guarantee of having obtained an optimum fit to any data, cannot measure the goodness of fit to the data and cannot provide quantitative estimates of uncertainty. One could therefore recommend that attention be paid to constructing a minimum realistic multispecies model for this region, covering only key interacting species. Such a model would be of more limited scope, but have the ability to be statistically fit the available data, giving greater accuracy and reliability for a limited set of problems. In such a case the Atlantis model could be used to identify the critical interacting components that should be included in the smaller statistically fitted model. In general Atlantis may perform best as part of a suite of overlapping models, each able to best perform particular tasks. Such an expanded research project may also facilitate the retaining of a core group of Atlantis researchers in order to avoid over-relying on any given individual.

It should be stressed that Atlantis models in general are better suited to give broad brush qualitative, rather than quantitative, advice. The model results should therefore not be taken as giving advice on exact quantities, stock levels, quota levels or reference points. In general, to avoid confusion, it would be wise in a management context to only present results as rankings or "% change from base case" rather than give exact (but highly unreliable) model outputs.

It is not clear how uncertainty can be realistically estimated within an Atlantis model. Further work should be devoted to attempting to solve this problem, perhaps by using multiple feasible solutions to give a qualitative understanding of the uncertainty range. However in the case that estimating uncertainty remains intractable, it is important that outputs should be used accordingly (especially when informing other models which do give uncertainty estimates), and the lack of uncertainty estimates be made obvious.

The review process was somewhat complicated by the ongoing update to the model. As such the main outcomes of the review were to highlight areas which should be improved in forthcoming versions and to speculate on possible uses. In this the review was largely successful, and it is likely that the review will prove helpful to the further development of the model. However it would perhaps have been better if the ToRs for the review had been framed with this in mind, rather than designed to evaluate a single, complete model version. The review has, in this researcher's opinion, been a success in spite of the ToRs rather than because of them.

Appendix 1: Bibliography of materials provided for review

Primary peer-reviewed documents

Fulton, E. A., Link, J. S., Kaplan, I. C., Savina-Rolland, M., Johnson, P., Ainsworth, C., Horne, P., et al. 2011. Lessons in modelling and management of marine ecosystems: the Atlantis experience. Fish and Fisheries, 12: 171–188.

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Kaplan, I. C., Brown, C. J., Fulton, E. A., Gray, I. A., Field, J. C., and Smith, A. D. 2013a. Impacts of depleting forage species in the California Current. Environmental Conservation 40(04): 380 – 393.

Kaplan, I.C. and Leonard, J. 2012. From krill to convenience stores: forecasting the economic and ecological effects of fisheries management on the US West Coast. Marine Policy 36: 947–954.

Kaplan, I.C., Horne, P.J. and Levin, P.S. 2012a. Screening California Current fishery management scenarios using the Atlantis end-to-end ecosystem model. Progress In Oceanography 102: 5–18.

Kaplan, I. C. Gray, I. A. and P. S. Levin. 2012b. Cumulative impacts of fisheries in the California Current. Fish and Fisheries, 14: 515–527.

Isaac C. Kaplan, Daniel S. Holland, and Elizabeth A. Fulton. 2014. Finding the accelerator and brake in an individual quota fishery: linking ecology, economics, and fleet dynamics of US West Coast trawl fisheries. ICES Journal of Marine Science, 71(2), 308–319.

Primary technical documents

Horne, P., Kaplan, I.C., Marshall, K., Levin, P. S., and Fulton, E.A., 2010. Central California Atlantis Model (CCAM): Design and Parameterization. US Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-104.

Kaplan I.C, K.N. Marshall, E. Hodgson, L. Koehn. Update for 2014 Methodology Review: Ongoing Revisions to the Spatially Explicit Atlantis Ecosystem Model of the California Current (Document developed for Methodology review)

Dufault, A., Marshall, K.M., and Kaplan, I.C. 2009. A Synthesis of Diets and Trophic Overlap of Marine Species in the California Current. U.S. Dept. Commer., NOAA Technical Memorandum NMFSNWFSC-103.

Additional technical document supplied on request.

Kaplan, I.C., Wells, B., and Curchitser, E. 2013b. Summary of Existing California Current Ecosystem Models for: PACIFIC COUNCIL WORKSHOP ON PACIFIC SARDINE MANAGEMENT STRATEGY AND HARVEST CONTROL PARAMETERS

Additional Atlantis documents

Brand, E. J., I. C. Kaplan, C. J. Harvey, P. S. Levin, E. A. Fulton, A. J. Hermann, and J. C. Field. 2007. A spatially explicit ecosystem model of the California Current's food web and oceanography. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-84.

Fulton, E. A. 2004. Biogeochemical marine ecosystem models II: The effect of physiological detail on model performance. Ecol. Model. 173:371–406.

Fulton, E.A., Smith A.D.M., Smith D.C., Johnson P. 2014. An Integrated Approach Is Needed for Ecosystem Based Fisheries Management: Insights from Ecosystem-Level Management Strategy Evaluation. PLoSONE9(1):e84242. doi:10.1371/journal.pone.0084242

Background on ecosystem modeling

FAO. 2008. Best practices in ecosystem modelling for informing an ecosystem approach to fisheries. FAO Fisheries Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2, Add. 1. Rome, FAO. 78p.

Levin P.S., Fogarty M.J., Murawski S.A., Fluharty D. 2009. Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. PLoS Biol 7(1): e1000014. doi:10.1371/journal.pbio.1000014.

Link J. S., T.F. Ihde, C.J. Harvey, S.K. Gaichas, J.C. Field, J.K.T. Brodziak, H.M. Townsend, R.M. Peterman. 2012. Progress in Oceanography 102 (2012) 102–114.

Peterman, R. M. 2004. Possible solutions to some challenges facing fisheries scientists and managers. ICES Journal of Marine Science, 61: 1331-1343.

Plagányi, É. E. 2007. Models for an ecosystem approach to fisheries. FAO Fisheries Technical Paper. No. 477. Rome, FAO. 108 p.

Appendix 2: Statement of Work

External Independent Peer Review by the Center for Independent Experts

Review of the Atlantis Ecosystem Model in Support of Ecosystem-Based Fishery Management in the California Current Large Marine Ecosystem

BACKGROUND

The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

SCOPE

Project Description: The purpose of this review is to evaluate the performance characteristics and to identify appropriate management applications of an Atlantis ecosystem model, employed at NWFSC as an operating model in support of the development of Ecosystem-Based Fishery Management (EBFM) strategies for the California Current Large Marine Ecosystem. This review is being undertaken based on recommendations by the Scientific and Statistical Committee (SSC) of the Pacific Fishery Management Council (PFMC), who will chair the review panel.

NMFS strongly endorsed the concept of Ecosystem-Based Management and the related need for the development of Integrated Ecosystem Assessment in support of EBFM. Although this review is directed at efforts in the NWFSC, and more specifically the PFMC, the findings will be more broadly applicable on the West Coast and throughout the agency.

The objectives of the methodology review meeting are to evaluate the performance characteristics of this application of the Atlantis model, and to identify the extent to which this Atlantis ecosystem model is suitable as an operating model to provide strategic guidance related to NOAA management needs on the West Coast. Specific objectives of the SSC are to identify the strengths, weaknesses, and applicability of the model to particular questions and needs in order to facilitate use of Atlantis-generated products in the future.
These needs include evaluation of cumulative impacts of groundfish and pelagic fisheries, evaluation of risks of climate change and ocean acidification, ranking of potential fishery

management strategies, and formal Management Strategy Evaluation to 'simulation test' new methods of stock assessment, data collection, and decision making. The review will not focus on the Atlantis C++ code base, nor will it focus on data quality except as it pertains to model performance. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

OBJECTIVES

Requirements for the reviewers: Three reviewers shall conduct an impartial and independent peer review of the Atlantis ecosystem model provided, and this review should be in accordance with this SoW and the methodology review ToRs herein.

The reviewers shall have working knowledge and recent experience in the application of multi-species or ecosystem models of marine ecosystems. This application of Atlantis includes a full dynamic, spatial representation of the marine food web including ocean circulation, biogeochemistry and fisheries. Reviewers should have expertise with models that span these levels of complexity, at a minimum coupling several species to fisheries. Reviewers should have published or supervised development of at least two different types of such models (different model platforms or frameworks), though experiences with the Atlantis model itself is not a requirement. Reviewers shall have direct experience in model development with EBFM application, meaning direct senior level policy applications or recommendations in addition to scientific publications.

PERIOD OF PERFORMANCE

The reviewers shall conduct the tasks according to the schedule of milestones and deliverables as specified in this statement of work (SoW). Each reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein. The tentative schedule of milestones and deliverables is provided herein.

PLACE OF PERFORMANCE AND TRAVEL

Each reviewer shall conduct an independent peer review during the panel review meeting tentatively scheduled during June 30 – July 2, 2014 in Seattle, Washington.

STATEMENT OF TASKS

Each reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Tasks prior to the meeting: The contractor shall independently select qualified reviewers that do not have conflicts of interest to conduct an independent scientific peer review in accordance with the tasks and ToRs within the SoW. Upon completion of the independent reviewer selection by the contractor's technical team, the contractor shall provide the reviewer information (full name, title, affiliation, country, address, email, and FAX number) to the contractor officer's representative (COR), who will forward this information to the NMFS

Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The contractor shall be responsible for providing the SoW and stock assessment ToRs to each reviewer. The NMFS Project Contact will be responsible for providing the reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact will also be responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Foreign National Security Clearance: The reviewers shall participate during a panel review meeting at a government facility, and the NMFS Project Contact will be responsible for obtaining the Foreign National Security Clearance approval for the reviewers who are non-US citizens. For this reason, the reviewers shall provide by FAX (not by email) the requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/.

Pre-review Background Documents: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the COR the necessary background information and reports (i.e., working papers) for the reviewers to conduct the peer review, and the COR will forward these to the contractor. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the COR on where to send documents. The reviewers are responsible only for the pre-review documents that are delivered to the contractor in accordance to the SoW scheduled deadlines specified herein. The reviewers shall read all documents deemed as necessary in preparation for the peer review.

Tasks during the panel review meeting: Each reviewer shall conduct the independent peer review in accordance with the SoW and stock assessment ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and contractor.** Each reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the methodology review ToRs as specified herein. The NMFS Project Contact will be responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact will also be responsible for ensuring that the Chair understands the contractual role of the reviewers as specified herein. The contractor can contact the COR and NMFS Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting tentatively scheduled in Seattle, Washington during June 30 through July 2, 2014.
3) During the panel review, conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than 16 July 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Die ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

DELIVERY

Each reviewer shall complete an independent peer review report in accordance with the SoW. Each reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each reviewer shall complete the independent peer review addressing each stock assessment ToR listed in **Annex 2**.

Tentative Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

26 May 2014	Contractor sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
16 June 2014	NMFS Project Contact provides reviewers the pre-review documents
30 June – 2 July 2014	Each reviewer participates and conducts an independent peer review during the panel review meeting in Seattle, WA
16 July 2014	Reviewers submit draft independent peer review reports to the contractor's technical team for independent review
30 July 2014	Contractor submits independent peer review reports to the COR who reviews for compliance with the contract requirements
6 August 2014	The COR distributes the final reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: The deliverables shall be the final peer review report from each reviewer that satisfies the requirements and terms of reference of this SoW. The contract shall be successfully completed upon the acceptance of the contract deliverables by the COR based on three performance standards:

(1) each report shall be completed with the format and content in accordance with **Annex 1**,
(2) each report shall address each stock assessment ToR listed in **Annex 2**,
(3) each report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Upon the acceptance of each independent peer review report by the COR, the reports will be distributed to the NMFS Project Contact and pertinent NMFS science director, at which time the reports will be made publicly available through the government's website.

The contractor shall send the final reports in PDF format to the COR, designated to be William Michaels, via email William.Michaels@noaa.gov

Support Personnel:

William Michaels, Program Manager, COR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

Key Personnel:
Mindi Sheer, IEA Coordinator,
Northwest Fisheries Science Center
2725 Montlake Blvd. E,
Seattle, WA 98112
Mindi.Sheer@noaa.gov Phone: 206-860-3428

Stacey Miller, Groundfish Stock Assessment Coordinator
Northwest Fisheries Science Center
55 Great Republic Drive,
Gloucester MA
Stacey.Miller@noaa.gov Phone: 978-281-9203

Annex 1: Format and Contents of Independent Peer Review Report

1. The independent peer review report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The main body of the report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Findings of whether they accept or reject the work that they reviewed, and an explanation of their decisions (strengths, weaknesses of the analyses, etc.) for each ToR, and Conclusions and Recommendations in accordance with the ToRs. For each assessment reviewed, the report should address whether each ToR of the SAW was completed successfully. For each ToR, the Independent Review Report should state why that ToR was or was not completed successfully. To make this determination, the SARC chair and reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the SARC Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the SARC Summary Report. The independent report shall be an independent peer review of each ToR, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of this Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Tentative Terms of Reference

Review of the Atlantis Ecosystem Model in Support of Ecosystem-Based Fishery Management in the California Current Large Marine Ecosystem

The reviewers will participate in the Panel review meeting to conduct independent peer reviews of the Atlantis ecosystem model for the California Current marine ecosystem. The review solely concerns technical aspects of the methods, and addresses the following ToR:

ToR 1 – Review documents detailing Atlantis ecosystem model methodologies according to the PFMC ToR for the Methodology Review Process for Groundfish and Coastal Pelagic Species. Evaluate if the documented and presented information is sufficiently complete. Document the meeting discussions and contribute to a summary panel report.

ToR 2 – Evaluate the technical merits and deficiencies of the proposed method(s) taking into consideration the data requirements of each method, the conditions under which the method is applicable, the assumptions of each method, and the robustness of model results to departures from model assumptions and atypical data inputs. Recommend alternative methods or modifications to the proposed methods, or both, during the panel meeting. Recommendations and requests for additional or revised analyses during the panel meeting must be clear, explicit, and in writing. Comment on the degree to which the methods describe and quantify the sources of uncertainty in the results.

ToR 3 – Evaluate technical merits and deficiencies of the application of the methodologies.

ToR 4 – Decide through Panel discussions if the ToRs and goals of the peer review have been achieved and determine whether the science reviewed is considered to be the best scientific information available. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all of the ToRs must be described in the Summary Panel Report and CIE Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

ToR 5 - Provide specific suggestions for future improvement in any relevant aspects of data collection and treatment, modeling approaches and technical issues.

Annex 3: Tentative Agenda

(Final agenda to be provided two weeks prior to the meeting)

Review of the Atlantis Ecosystem Model in Support of Ecosystem-Based Fishery Management in the California Current Large Marine Ecosystem

Tentatively scheduled in Seattle, Washington

Tuesday, July 1, 2014

8:30 a.m. Welcome and Introductions

8:45 a.m. Review the Draft Agenda and Discussion of Meeting Format (Panel Chair)

- Review Terms of Reference for Assessment and Review Panel
- Assignment of reporting duties
- Discuss and agree to format for the final assessment document

9:00 a.m. Presentation of Model

- Overview of data and modeling approach
- Q & A session with STAT
- Panel discussion

Wednesday, July 2, 2014

Thursday, July 3, 2014

Appendix 3: Panel Membership or other pertinent information from the panel review meeting

Methodology Review Panel Members:
Kerim Aydin, AFSC
Kenneth Frank, CIE, Fisheries and Oceans Canada
Martin Dorn (Chair), SSC, AFSC
Daniel Howell, CIE, Institute of Marine Research
Galen Johnson, SSC, Northwest Indian Fisheries Commission
Pete Lawson SSC, NWFSC
Andre Punt, SSC, University of Washington
Will Satterthwaite, SSC, SWFSC
Tien-Shui Tsou, SSC, Washington Department of Fish and Wildlife
Cindy Thomson, SSC, SWFSC
Reg Watson, CIE, University of Tasmania

Pacific Fishery Management Council (Council) Representatives:
Kit Dahl, Council Staff

Atlantis Technical Team:
Isaac Kaplan, NWFSC
Kristin Marshall, National Research Council, NWFSC, University of Washington
Chris Harvey, NWFSC
Phil Levin, NWFSC
Al Hermann, University of Washington